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SPECIFICATION

TO ALL WHOM IT MAY CONCERN:

BE IT KNOWN THAT WE, TAKAHIRO YAGISHITA, a citizen of Japan residing at Kanagawa, Japan, YUKIKO YAMAZAKI, a citizen of Japan residing at Kanagawa, Japan and NEKKA MATSUURA, a citizen of Japan residing at Tokyo, Japan have invented certain new and useful improvements in

EFFICIENT CODING OF COLOR IMAGES INCLUDING
MONOCHROME IMAGES

of which the following is a specification:-

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention generally relates to
5 image processing devices, and particularly relates to an
image processing devices which compresses and encodes
color images.

2. Description of the Related Art

In the field of data processing and data
10 communication, data compression and encoding techniques
are widely used for the purpose of reducing memory size
required for storing image data and of shortening
transmission time when transmitting image data.

In image forming devices such as digital
15 copiers, there is a need to perform editing processes at
high speed within limited memory space, such editing
processing including rotation, combination,
superimposition, size change, etc., of images, and
fixed-length compressing and encoding techniques are
20 employed to this end. This is because a fixed-length
encoding results in memory addresses of stored encoded
data being easily identified with respect to a position
of interest within the image to be edited. Further, in
the case of digital copiers having a function of
25 electric sorting, there is a need to store a plurality

of images in a memory, resulting in a need for large memory size.

In general, the amount of information representing a monochrome image is smaller than the 5 amount of information representing a color image. Use of appropriate encoding schemes results in a higher coding rate being obtained for the monochrome image. Devices for processing color image data do not always process color images, but occasionally process 10 monochrome images. Applying the same encoding technique to monochrome images as applied to color images is not desirable in terms of coding efficiency. Accordingly, it is desirable to use different encoding schemes for monochrome images and color images, respectively.

15 An image coding device disclosed in Japanese Patent No. 2,520,891 checks whether each block obtained by dividing an input image is a monochrome image or a color image. If a block is ascertained as a monochrome image, brightness information of the coded image data 20 can be stored in an increased amount as color information does not exist in a monochrome image. Further, the memory space spared by absence of color information may be used for storing brightness information of the next block. If not necessary to 25 exploit all the spared space, filler bits may be placed

without a concern for a decrease in efficiency.

Further, an image coding device disclosed in Japanese Patent No. 2,618,944 increases the number of quantization bits for brightness information in monochrome blocks so as to have the same number of quantization bits for one monochrome block as for one color block. Alternatively, the number of quantization bits for brightness information in monochrome blocks is set to half the number of quantization bits for brightness information in color blocks, thereby adjusting the total number of bits in image blocks.

The image coding devices disclosed in Japanese Patent No. 2,520,891 and in Japanese Patent No. 2,618,944 employ different encoding schemes between monochrome images and color images, so that separate encoding means are necessary for respective images. Further, an improvement in coding efficiency is attained only when an image is comprised of a predetermined single color, so that the field of application is not as wide as desired. When an encoding technique that outputs a shorter length of codes for monochrome (black and white) images is applied to a blue only image, such an encoding technique does not produce a shorter length of codes, failing to achieve an improvement in coding efficiency. If an attempt is made to check the color of

the image, an extra time becomes necessary for such data processing, thereby hampering efforts toward high-speed encoding processing. If the distribution of color components is measured throughout the entire image prior 5 to commencement of the encoding processing, for example, the start of encoding processing must be delayed by the time length required for such data processing.

Further, when a single image contains monochrome blocks as well as color blocks, the resulting 10 codes for each block may differ from block to block. Namely, features of fixed-length coding are lost, with increased difficulties in performing various editing processes on the image data.

Accordingly, there is a need for an image 15 processing device which can encode image data including color images and monochrome images at high speed and at high coding rate.

SUMMARY OF THE INVENTION

It is a general object of the present 20 invention to provide an image processing device that substantially obviates one or more of the problems caused by the limitations and disadvantages of the related art.

Features and advantages of the present 25

invention will be set forth in the description which follows, and in part will become apparent from the description and the accompanying drawings, or may be learned by practice of the invention according to the
5 teachings provided in the description. Objects as well as other features and advantages of the present invention will be realized and attained by the image processing device particularly pointed out in the specification in such full, clear, concise, and exact
10 terms as to enable a person having ordinary skill in the art to practice the invention.

To achieve these and other advantages and in accordance with the purpose of the invention, as embodied and broadly described herein, the invention
15 provides a device for processing images including a compressing/coding unit which encodes image data including a plurality of color components to produce fixed-length codes, a memory unit which stores therein the codes produced by the compressing/coding unit, a
20 distribution-measurement unit which measures a distribution of the color components concurrently with the encoding of the image data performed by the compressing/coding unit, and a memory-control unit which releases a memory space assigned to part of the codes
25 relating to colors in the memory unit if the

distribution-measurement unit detects that the distribution concentrates on a particular color composition, and records data indicative of the particular color composition in the memory unit.

5 In the device described above, a check as to whether the input image is a monochrome image is performed concurrently and in parallel with the process of compressing and encoding the image, and part of the memory space relating to the color codes is released in
10 response to the check results indicative of a monochrome image after the compressed and encoded codes are stored in the memory. This improves coding efficiency for monochrome images. Further, since the check processing and the compression and encoding processing are carried
15 out simultaneously, no extra time for the sake of performing the checking process is necessary, thereby achieving high-speed and efficient coding. Further, since the data indicative of the particular color composition is stored in the memory unit in the case of
20 a monochrome image, the original image can be correctly reconstructed at the time of decoding processes despite the deletion of the color codes.

The present invention is also directed to an image processing system, an image coding method, and a
25 memory medium having a program recorded therein for

practicing the image coding method, as will be described in the following description.

BRIEF DESCRIPTION OF THE DRAWINGS

- 5 Fig.1 is a block diagram of an image processing device according to a first embodiment of the present invention;
- Fig.2 is an illustrative drawing for explaining an example of sub-band conversion;
- 10 Fig.3 is an illustrative drawing showing an example of bit assignment to sub-band-conversion coefficients;
- Fig.4A is an illustrative drawing showing areas of counting used when the distribution of chrominance components are counted;
- 15 Fig.4B is an illustrative drawing showing an example of counting results obtained by counting the distribution of chrominance components;
- Fig.5 is a chart showing an example of the distribution of chrominance components;
- 20 Fig.6 is a flowchart showing a process of determining whether a ratio of a maximum count to a total count exceeds a predetermined value;
- Fig.7 is a block diagram showing an example of a configuration of a distribution-measurement unit shown

in Fig.1;

Fig.8 is an illustrative drawing for explaining the way a memory-control unit stores three pages' worth of codes at specified addresses;

5 Fig.9 is a block diagram of an image processing device according to a second embodiment of the present invention;

Fig.10 is a block diagram of an image processing system to which the image processing device
10 of the present invention is applied; and

Fig.11 is an illustrative drawing showing a configuration of a device that performs the image processing method of the present invention.

15 **DESCRIPTION OF THE PREFERRED EMBODIMENTS**

In the following, embodiments of the present invention will be described with reference to the accompanying drawings.

Fig.1 is a block diagram of an image processing device according to a first embodiment of the present invention.

The image processing device 10 of Fig.1 includes an image coding unit 11, an image decoding unit 12, a memory unit 13, a distribution-measurement unit 14,
25 and a memory-control unit 15.

RGB image data read by a scanner or the like is encoded and compressed by the image coding unit 11 so as to produce fixed-length codes, which are stored in the memory unit 13. In the memory unit 13, editing processes such as rotation, combination, size change, etc., are performed on the images if necessary. At the time of printing, the data stored in the memory unit 13 is returned to the original RGB data by the image decoding unit 12. Thereafter, the image data is subjected to image-quality correction, color-conversion into CMYK data, gray-level correction, etc., followed by being supplied to and printed by a printer.

The image coding unit 11 includes a block-division unit 21, a color conversion unit 22, a sub-band conversion unit 23, and a quantization unit 24. The image decoding unit 12 includes an inverse quantization unit 31, an inverse sub-band conversion unit 32, an inverse color conversion unit 33, and a buffer unit 34.

In Fig.1, the color image signals (R, G, B) read by the scanner or the like are supplied to the image coding unit 11 as raster scans. The block-division unit 21 of the image coding unit 11 temporarily buffers the color image signals (R, G, B), and, then, cuts out a portion of image data by a block unit such as a 2-pixel-by-2-pixel block unit. Each block of the

image data is supplied to the data encoding and compressing processing at the subsequent stages.

The color conversion unit 22 of the image coding unit 11 linearly converts the RGB data supplied 5 block by block into color-space signals Y, Cb, and Cr representing brightness and chrominance. This linear conversion is shown in the following.

$$Y = 0.30 R + 0.59 G + 0.11 B$$

$$Cb = 0.56 (B-Y)$$

$$10 \quad Cr = 0.71 (R-Y)$$

In association with this, the inverse color conversion unit 33 of the image decoding unit 12 performs the inverse of the conversion shown above by equations as follows.

$$15 \quad R = Y + 2 (1 - 0.299) Cr$$

$$B = Y + 2 (1 - 0.114) Cb$$

$$G = (Y - 0.299R - 0.114B) / 0.587$$

When the color conversion unit 22 of the image coding unit 11 performs the color conversion as 20 described above, statistical power of images is concentrated on the luminance signal Y, thereby reducing entropy.

Thereafter, the sub-band conversion unit 23 of the image coding unit 11 attends to sub-band conversion 25 of the Y, Cb, and Cr signals obtained by the color

conversion. The following is one of the simplest examples of the sub-band conversion.

$$\text{LPF} : S(n) = (x(2n) + x(2n+1)) / 2$$

$$\text{HPF} : D(n) = x(2n) - x(2n+1)$$

- 5 The inverse of this sub-band conversion is carried out by the following equations.

$$x(2n) = S(n) + D(n)/2$$

$$x(2n+1) = S(n) - D(n)/2$$

- Fig.2 is an illustrative drawing for
10 explaining the example of the sub-band conversion.

In Fig.2, the high-pass filter $D(n)$ is applied to an original image in a horizontal direction. Concurrently with this filtering, the low-pass filter $S(n)$ is applied to the original image in the horizontal direction. Thereafter, the high-pass filter $D(n)$ is further applied in a vertical direction to the outputs of the high-pass filter $D(n)$ applied in the horizontal direction to obtain diagonal high-band components HH , and the low-pass filter $S(n)$ is concurrently applied to obtain vertical high-band components LH . Further, the high-pass filter $D(n)$ is applied in the vertical direction to the outputs of the low-pass filter $S(n)$ applied in the horizontal direction to obtain horizontal high-band components HL , and the low-pass filter $S(n)$ is concurrently applied to obtain low-band components LL .

In this manner, the horizontal high-band components HL, the vertical high-band components LH, the diagonal high-band components HH, and the low-band components LL are obtained as four frequency-band signals. Since power focuses on the low-band components LL, the low-band components LL tend to have relatively large values and contain the relatively large amount of information. If the sub-band conversion is applied to the low-band components LL recursively, further reductions in entropy can be attained.

The conversion coefficients obtained by the sub-band conversion unit 23 as described above are supplied to the quantization unit 24.

The quantization unit 24 quantizes the coefficients by using the predetermined numbers of quantization bits, and results of the quantization are stored in the memory unit 13. Here, the total number of quantization bits assigned to the conversion coefficients is fixed for one block.

Fig.3 is an illustrative drawing showing an example of bit assignment to the sub-band-conversion coefficients by the quantization unit 24.

Fig.3 shows a case in which a 2-pixel x 2-pixel block with 8 bits per pixel is processed with respect to each of the R, G, and B colors (96 bits in

total). After the color conversion and the sub-band conversion, the luminance signal Y has 8 bits assigned to LL thereof, 3 bits assigned to HL and LH thereof, and 2 bits assigned to HH thereof. Further, each of the 5 chrominance signals Cb and Cr has 8 bits assigned to LL thereof and 0 bit assigned to HL, LH, and HH components thereof. As a result, the total number of quantization bits is 32 in this case. Since the number of bits in the original image block is 96 bits, the rate of 10 compression in this case is 3 (= 32/96).

Here, the low-band components LL of the luminance signal Y are brightness information indicative of brightness of a given block, and the HL, LH, and HH components of the luminance signal Y are structure 15 information indicative of spatial luminance pattern within the given block. Further, the low-band components LL of the chrominance signals Cb and Cr are color information representing colors of the given block.

As shown in Fig.3, the quantization unit 24 20 assigns the predetermined numbers of bits to the respective components so as to achieve a fixed-length compression of each block. Because of this, it is easy to obtain addresses at the time of editing of images stored in the memory unit 13, thereby making it possible 25 to achieve high-speed processing.

As long as the total number of bits assigned to each block is constant, it is not necessary to assign the fixed numbers of bits to respective components within a given block. Namely, assignment of bits to the 5 components may be changed from block to block. When bit assignment is changed depending on locations within an image, the fixed-length coding can attain a further improvement in coding efficiency. In this case, area-attribute information indicative of areas may be added 10 to the fixed-length codes.

As is described in connection with the description of the related art, a monochrome image comprised of only black and white or a single color such as blue may be entered in a device or system that is 15 designed to handle color images. In such a case, it is desirable to perform compressing and encoding processing particularly appropriate for monochrome images.

In consideration of this, the present invention includes the distribution-measurement unit 14 20 as shown in Fig.1. The distribution-measurement unit 14 measures the distribution of the chrominance components Cb and Cr over the entire image, and checks whether the obtained distribution has a concentration within a predetermined range. Namely, a check is made as to 25 whether the distribution concentrates on a particular

composition of color components. A composition of the chrominance components Cb and Cr determines a color. If the distribution concentrates on a particular composition of chrominance components, therefore, it is
5 reasonable to ascertain that the input image is a monochrome image.

It should be noted that the distribution-measurement processing by the distribution-measurement unit 14 is concurrently performed with the compressing
10 and encoding processing previously described.

Fig.4A is an illustrative drawing showing areas of counting used when the distribution of the chrominance components Cb and Cr are counted. Fig.4B is an illustrative drawing showing an example of the
15 counting results obtained by counting the distribution of the chrominance components Cb and Cr.

As shown in Fig.4A, the plane defined by the chrominance components Cb and Cr is divided into a plurality of areas corresponding to different
20 compositions of colors (i.e., 24 areas corresponding to 24 different compositions of chrominance components in this example). Then, the number of occurrences is counted within each area with respect to the entirety of the image. It should be noted, however, that the area
25 including the black-and-white monochrome ($Cb = Cr = 0$)

is not subjected to the counting. C_1 through C_{24} in Fig.4A indicate the numbers of occurrences in respective areas.

After the counting process as described above,
5 a ratio of the largest count to the total count is obtained.

When the counts are standardized by the total count so as to represent ratios of counts to the total count, results as shown in Fig.4B may be obtained. In
10 an example of Fig.4B, a ratio of the count C_9 , to the total count is 87%, and this is the largest ratio. Namely, when the distribution concentrates on a particular composition of colors, it is ascertained that the input image is a monochrome image (i.e., a single
15 color image).

Fig.5 is a chart showing an example of the distribution of the chrominance components C_b and C_r .

As shown in Fig.5, 87% of all the pixels belong to the same single area of the chrominance
20 components in this example. Among the rest, 8% belong to another area of the chrominance components. A check is made a to whether the ratio of the maximum count to the total count as represented as 87% in this example exceeds a predetermined percentage.

25 Fig.6 is a flowchart showing a process of

determining whether the ratio of the maximum count to the total count exceeds a predetermined value.

In Fig.6, " C_i " represents the number of occurrences in each area obtained by dividing the plane defined by the chrominance components C_b and C_r , and "sum" indicates a total sum of occurrences. Further, "max" represents a maximum count, and "max_i" is an index indicative of an area that has the maximum count.

At a step S1, "max" is set to 0, and "max_i" and a parameter "i" are set to 1.

At a step S2, the number of occurrences C_i is added to the sum "sum" so as to obtain the total sum of the occurrences that have been counted so far.

At a step S3, a check is made as to whether the number of occurrences C_i is greater than the maximum count "max" that has obtained so far. If it is greater, the procedure goes to a step S4. Otherwise, the procedure skips the step S4.

At the step S4, the number of occurrences C_i is recorded as a new maximum count "max", and the index "max_i" indicative of an area that marked the maximum count is set to "i".

At a step S5, "i" is incremented by one.

At a step S6, a check is made as to whether the ratio of the maximum count to the total sum

(max/sum) exceeds 80%. If the ratio exceeds 80%, it is ascertained that the input image is a monochrome image, and the procedure goes to a step S8. If the ratio goes below 80%, it is ascertained that the input image is not 5 a monochrome image, and the procedure comes to an end. It should be noted that the threshold does not have to be 80%, and may be any appropriate value assigned in advance.

At a step S8, a memory space for color 10 information is released, and the information "max_i" regarding the composition of colors of the monochrome image is stored in the memory.

Then, the procedure comes to an end.

The process at the step S8 is carried out by 15 the memory-control unit 15 of Fig.1.

Fig.7 is a block diagram showing an example of a configuration of the distribution-measurement unit 14.

The distribution-measurement unit 14 of Fig.7 includes a quantization unit 101, a quantization unit 20 102, a selector 103, counters 104-1 through 104-24, and a monochrome-image-check unit 105. The quantization unit 101 and the quantization unit 102 receive the chrominance components Cb and Cr of each pixel from the color conversion unit 22, respectively, and quantize 25 them. The number of bits after the quantization is 3

bits in this example, with the 3 bits obtained after the quantization of Cb representing 5 columns in the Cb direction as shown in Fig.4A, and with the 3 bits obtained after the quantization of Cr representing 5 rows in the Cb direction. The 3 bits obtained after the quantization of Cb is combined with the 3 bits obtained after the quantization of Cr to generate 6 bit data, which are supplied to the selector 103 to select one of the 24 counters 104-1 through 104-24. Here, the counters 104-1 through 104-24 correspond to the 24 areas that are obtained by dividing the plane of the chrominance components shown in Fig.4A.

A clock signal is supplied to the counters 104-1 through 104-24 as shown in Fig.7. This clock signal is in synchronization with timings at which the chrominance data of each pixel is supplied from the color conversion unit 22 to the quantization units 101 and 102. When the chrominance data of a given pixel is supplied, the selector 103 selects a counter that corresponds to an area corresponding to the chrominance data. As a result, the selected counter is counted up by the clock signal.

As chrominance data of pixels are successively supplied, corresponding counters are successively selected and counted up until the counting operation for

all the pixels is completed. Consequently, the numbers of occurrences are obtained with respect to the plurality of areas, which divide the plane defined by C_b and C_r .

5 The monochrome-image-check unit 105 receives respective counts from the counters 104-1 through 104-24, and obtains a maximum count, followed by checking whether the maximum count accounts for more than 80% of the total count. Namely, a check is made as to whether
10 the maximum count that is the largest of all the counts obtained for the plurality of areas accounts for more than 80% of the total counts. If it accounts for more than 80%, the monochrome-image-check unit 105 outputs a monochrome-indication signal MONO indicating that the
15 input image is a monochrome image, and further outputs an index max_i indicative of an area that marked the maximum count. The index max_i represents a position of the area that corresponds to the maximum count among the 24 areas dividing the chrominance plane, and indicates
20 the composition of color components of the input monochrome image. Hereinafter, the information represented by this index is referred to as monochrome information.

The monochrome-indication signal MONO and the
25 monochrome information max_i are supplied to the memory-

control unit 15. The memory-control unit 15 controls writing of code data at specified addresses in the memory unit 13 when the code data is supplied from the quantization unit 24. The memory-control unit 15
5 further controls the memory unit 13 to release a memory space for chrominance codes if the monochrome-indication signal MONO indicates that the input image is a monochrome image. Further, the memory-control unit 15 controls the memory unit 13 to write the monochrome
10 information max_i at a predetermined address.

Fig.8 is an illustrative drawing for explaining the way the memory-control unit 15 stores three pages' worth of codes at specified addresses.

As previously described, the distribution-
15 measurement unit 14 performs the distribution- measurement process at the same time as the image coding unit 11 performs the fixed-length compressing and coding process.

As shown at the leftmost side of the figure,
20 at the timing indicated as T1, the quantization coefficients of the luminance component Y1 and the chrominance components C1 that correspond to the first page are stored from the beginning of memory space in the memory unit 13. Concurrently with this, the
25 distribution-measurement unit 14 performs the

distribution-measurement processing, and checks whether the first page is a monochrome image.

When it is ascertained that the input image is a monochrome image, a memory space for the codes of the 5 chrominance components C1 is released among the fixed-length codes stored in the memory unit 13, as shown at a timing T2 of Fig.8. Releasing of the memory space does not necessarily involve clearing of the memory space, and it may suffice only if the memory space is marked as 10 available for other use. At the same time as the releasing of the memory space, monochrome information (i.e., the index max_i indicative of an area that marked the maximum count) is stored at a predetermined address in the memory.

15 At a timing T3 of Fig.8, the codes of the luminance component Y2 corresponding to the second page are written from the beginning of the memory space released from the chrominance components of the first page, according to memory addresses specified by the 20 memory-control unit 15. Following this, the chrominance components C2 of the second page are stored in the memory.

In the example shown in Fig.8, the second page is a color page, and the third page is a monochrome page. 25 As a result, as shown at a timing T4, the luminance

component Y3 and the chrominance components C3 of the third page are stored next following the chrominance components C2 of the second page. The chrominance components C3 of the third page are then released as
5 shown at a timing T5.

At a time of image decoding, the image decoding unit 12 obtains the chrominance components Cb and Cr from the index max_i indicative of the area of a maximum count, and uses these chrominance components Cb
10 and C4 over the entire image to complete the decoding processing. This makes it possible to reconstruct the original monochrome image despite the elimination of chrominance code data.

In this manner, a check as to whether the
15 input image is a monochrome image is performed concurrently and in parallel with the process of compressing and encoding the image, and part of the memory space is released in response to the check results indicative of a monochrome image after the
20 compressed and encoded codes are stored in the memory. This improves a coding efficiency for monochrome images. Further, since the check processing and the compression and encoding processing are carried out simultaneously, no extra time for the sake of performing the checking
25 process is necessary, thereby achieving high-speed and

efficient coding. Further, since the monochrome check of the present invention is not made by comparing an input image with any predetermined particular composition (e.g., $C_b = C_r = 0$), the check process is
5 applicable to any single-color composition.

Fig.9 is a block diagram of an image processing device according to a second embodiment of the present invention. In Fig.9, the same elements as those of Fig.1 are referred to by the same numerals, and
10 a description thereof will be omitted.

An image processing device 10A of Fig.9 includes an image coding unit 11A, an image decoding unit 12A, the memory unit 13, the distribution-measurement unit 14, and the memory-control unit 15.

15 The image coding unit 11A includes the block-division unit 21, a sub-band conversion unit 23A, and a quantization unit 24A. The image decoding unit 12A includes an inverse quantization unit 31A, an inverse sub-band conversion unit 32A, and the buffer unit 34.

20 Color image signals (R, G, B) are supplied to the block-division unit 21 of the image coding unit 11A. The block-division unit 21 supplies the color image signals (R, G, B) to the sub-band conversion unit 23A block by block.

25 The sub-band conversion unit 23A applies sub-

band conversion separately to each color component of the R, G, and B data without any color conversion. The sub-band conversion itself is the same as that applied to each of the Y, Cb, and Cr signals obtained after the
5 color conversion in the first embodiment. The quantization unit 24A quantizes the coefficients obtained by the sub-band conversion in a similar manner to that of the first embodiment.

Before the color image signals (R, G, B) are
10 supplied from the block-division unit 21 to the distribution-measurement unit 14, subtraction units 41 and 42 compute subtractions (R-G) and (B-G), respectively. The distribution-measurement unit 14 measures the distribution of (R-G) and (B-G) over the
15 entire image, and checks whether the distribution has a concentration within a predetermined range.

In the same manner as was described in connection with Fig.4 through Fig.6, occurrences are counted over the plane defined by (R-G) and (B-G), and a
20 ratio of a maximum count to a total count is obtained. If the ratio exceeds a predetermined value, the image is ascertained as a monochrome image. Also, information regarding the area of a maximum count is stored in the memory in addition to the fixed-length codes. If the
25 check results find that the input image is a monochrome

image, a memory space assigned to R component codes and B component codes is released among the memory space for the fixed-length compressed codes.

At the time of image decoding, data of (R-G) 5 and (B-G) corresponding to the area of a maximum count is obtained from the memory, and is applied to every part of the image. Namely, the processing in this case is space invariant processing. R and B in each image area are reconstructed from the data of (R-G) and (B-G) 10 that are space invariant and the data of G that is space variant. Thereafter, decoding processing is carried out.

A big difference between the first embodiment and the second embodiment is whether the image data R, G, and B are converted into Y, Cb, and Cr signals. The 15 second embodiment is based on the assumption that G is a proper approximation for Y, and so are (R-G) and (B-G) for Cr and Cb, respectively, without an exact color conversion. Color conversion will achieve higher efficiency in the coding process, but requires an extra 20 circuit, an extra processing time, and extra cost for the conversion processing.

It should be noted that the conversion process used for the fixed-length coding is not limited to the sub-band conversion, but may be the DCT (discrete cosine 25 transform), the Hadamard conversion, the BTC (block

truncation coding), etc.

The quantization method of quantizing the conversion coefficients is not limited to that used in the embodiments described above. For example,

5 quantization bits may be allocated to the high-band coefficients HL, LH, and HH of the chrominance components Cb and Cr. In this case, the high-band coefficients are referred to as structure information, and the low-band coefficients LL of the chrominance

10 components Cb and Cr are referred to as color information.

Further, the distribution measurement process may be performed over the entire page, or may be carried out with respect to each of local areas defined within

15 the same page. When the page is divided, fixed-length codes are produced with respect to each area, so that an ease of manipulating images is maintained, and so is an improvement of coding efficiency for a monochrome image.

Fig.10 is a block diagram of an image processing system to which the image processing device of the present invention is applied.

The image processing system of Fig.10 implements a digital color copier or the like, and includes a scanner 51, the image processing device 10 of Fig.1 (or the image processing device 10A of Fig.9), a

correction processing unit 52, a color-conversion-gray-area-processing unit 53, a plotter 54, and an editing unit 55.

The scanner 51 reads an original image, and
5 supplies color image signals (R, G, B) to the image processing device 10 (or 10A). The image processing device 10 (or 10A) compresses and encodes the input image data, and stores the codes in the memory unit 13 as described in the previous embodiments. The editing
10 unit 55 performs editing processes such as rotation, combination, superimposition, size change, etc., on the image data within the limited memory space. Since the fixed-length coding scheme is employed, memory addresses of the coded data and positions within the image to be
15 edited can be easily matched. This helps to achieve high-speed editing processes.

At the time of printing, data stored in the memory unit 13 is returned to the original RGB data by the image decoding unit. Thereafter, the image data is
20 subjected to image-quality correction by the correction processing unit 52 and color-conversion into CMYK data and gray-level correction by the color-conversion-gray-area-processing unit 53, followed by being supplied to and printed by the plotter 54.

25 When the present invention is applied to the

image processing system such as a digital color copier as described above, a check as to whether the input image is a monochrome image is performed concurrently and in parallel with the process of compressing and 5 encoding the image, and part of the memory space is released in response to the check results indicative of a monochrome image after the compressed and encoded codes are stored in the memory. This improves a coding efficiency for monochrome images. Further, since the 10 check processing and the compression and encoding processing are carried out simultaneously, no extra time for the sake of performing the checking process is necessary, thereby achieving high-speed and efficient coding.

15 Moreover, the image processing method of the present invention may be performed through software programs running on a computer.

Fig.11 is an illustrative drawing showing a configuration of a device which performs the image 20 processing method of the present invention.

As shown in Fig.11, the device for practicing the image coding method of the present invention is implemented by a computer such as a personal computer or an engineering workstation.

25 The device of Fig.11 includes a computer 510,

a display device 520 connected to a computer 510, a communication apparatus 523, and an input device. The input device may include a keyboard 521 and a mouse 522. the computer 510 includes a CPU 511, a RAM 512, a ROM 5 513, a secondary memory device 514 such as a hard drive, a detachable-medium memory device 515, and an interface unit 516.

The keyboard 521 and mouse 522 serve to provide user interface, and receive various commands for 10 operating the computer 510 and user responses responding to requests from the computer 510. The display device 520 displays processing results obtained by the computer 510, and also displays various data that enable the user to interact with the computer 510. The communication 15 apparatus 523 is used to communicate with a remote site, and is comprised of a modem, a network interface, or the like.

The image coding method of the present invention is provided as a computer program executable 20 by the computer 510. The computer program is stored in a memory medium M that is detachably mounted to the detachable-medium memory device 515. The computer program is loaded from the memory medium M to the RAM 512 or to the secondary memory device 514 via the 25 detachable-medium memory device 515. Alternatively, the

computer program is stored in a memory medium (not shown) located at a remote site, and is loaded from the remote memory medium to the RAM 512 or to the secondary memory device 514 via the communication apparatus 523
5 and the interface unit 516.

When an instruction to execute the program is given by the user via the keyboard 521 and/or the mouse 522, the CPU 511 loads the program to the RAM 512 from the memory medium M, the remote memory medium, or the
10 secondary memory device 514. The CPU 511 uses an available memory space of the RAM 512 as a work area to execute the program loaded to the RAM 512, and carry out processes of the computer program while interacting with the user as necessary. The ROM 513 stores therein
15 control programs for controlling basic operation of the computer 510.

The computer program performs the steps of encoding image data including a plurality of color components to produce fixed-length codes, storing the
20 codes in a memory, measuring a distribution of the color components concurrently with the encoding of the image data, and releasing a memory space assigned to part of the codes relating to colors in the memory if the distribution concentrates on a particular color
25 composition, and recording data indicative of the

particular color composition in the memory. Further, the computer program is used for practicing the image coding methods described in connection with the above embodiments.

5 Further, the present invention is not limited to these embodiments, but various variations and modifications may be made without departing from the scope of the present invention.

The present application is based on Japanese
10 priority application No. 2000-264422 filed on August 31, 2000, with the Japanese Patent Office, the entire contents of which are hereby incorporated by reference.

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